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An Interpretation of Geologic Materials Encountered in the Boring of Borrego Water District Monitoring Well MW-3

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This TIR is primarily a working paper and is subject to revision or replacement.

INTRODUCTION

Borrego Water District (BWD) monitoring well number 3 (MW-3) was drilled May 18, 2004 using the direct rotary method by Rottman Drilling Company. MW-3 (Figures 1 and 2; State Well Number 11S06E23J002S; 33˚ 12’12.7”N, 116˚ 18’ 53.8”W) is located approximately 5,750 feet southeast of Yaqui Pass Road along Borrego Valley Road, about 600 feet north of Borrego Valley Road. This monitoring well was drilled 100 feet north of BWD production well ID-8 (State Well Number 11S06E23J001S) so that it could facilitate an aquifer test.

The boring for MW-3 was drilled to 344 feet below ground surface (bgs) and the well was completed to 325 feet bgs and screened between 175 and 325 feet bgs. BWD personnel Jerry Rolwing, Greg Holloway, and Cody Cox attended the drilling and collected all lithologic samples. Tim Ross of the California Department of Water Resources (DWR) arrived when drilling had reached a depth of about 80 feet and recorded observations of drilling conditions and lithologic materials encountered to the total depth of 344 feet. This document is an interpretation of the geology encountered in the borehole for MW-3 based on the Well Completion Report submitted by Rottman Drilling, the electric logs produced by Welenco Inc., and the observations of drilling conditions and descriptions of borehole cuttings samples collected during drilling recorded by Tim Ross.

The borehole for MW-3 was spudded at about 9:15 AM on Tuesday, May 18, 2004. BWD personnel were present and started collecting cuttings samples, which continued at 10-foot intervals throughout drilling. The materials collected were separated into 3 duplicate containers and marked according to the depth of the drill bit at the time of collection of the sample. One set of samples was delivered to Darby Vickery (Engineering Geologist) of DWR Division of Planning and Local Assistance in Sacramento, one set was delivered to DWR Southern District in Glendale, and one set of samples was retained by BWD in Borrego Springs.

After arrival on site, Tim Ross recorded field descriptions of cuttings samples and characteristics of drilling. In general, the boring encountered variably thick interbedded layers of coarser-grained materials (sand and gravel) with finer-grained materials (silt and clay). Based on the borehole cuttings and the electric logs, the materials encountered can be separated into three main zones or sequences:

- An upper zone of about 120 feet dominated by coarse-grained materials.
- A transition zone between about 120 feet and 240 feet bgs of interbedded fine- and coarse-grained materials.
- A lower zone from 240 to 344 feet bgs dominated by fine-grained materials.

DRILLING AND ELECTRIC LOG OBSERVATIONS

Upper Zone:

The upper 120 feet of material is a mixture of medium- to coarse-grained sand with a minor amount of silt and gravel. Rottman Drilling’s description generally notes fine- to coarse-grained sand throughout this upper zone, with lenses of brown clay, cobble, and gravel noted in some intervals. Upon completion of the well, the static water level was noted to be at 62 feet bgs. The spontaneous potential and resistivity logs indicate coarser-grained materials to about 10 feet bgs followed by about 30 feet of interbedded coarser and finer layers (likely sandy and silty beds) ranging in thickness from less than 1 foot to about 5 feet. The resistivity curves suggest that between about 40 and 120 feet bgs, materials are dominantly coarse grained (probably sand size materials). This matches well with the descriptions of the cuttings, which indicate that these materials are generally medium- to coarse-grained sand with some fine gravel size clasts. Between about 60 and 80 feet bgs, the materials collected are fine- to coarse-grained sands with some silt and the character of the electric log curves suggests that these are probably coarse-grained sands mixed or interbedded with fine-grained sand and silty layers. The character of the electric logs suggests that the materials contain relatively less fine-grained material through an interval of about 80 to 110 feet bgs, whereas, the materials become finer-grained at about 120 feet bgs.

Transition Zone:

At about 130 feet bgs, the materials collected during drilling change to sands mixed with silts and clays. The cutting material collected from about 135 feet bgs can be rolled into a thin thread, indicating significant clay content. Electric log curves suggest that fine-grained materials (probably silt and clay) become dominant at about 120 feet bgs, with a general increase in fine-grained materials to about 240 feet bgs. A general decrease in resistivity suggests an overall trend toward smaller size grains, but the character of the curves indicate an interbedded nature of relatively finer and coarser materials.

Based on the resistivity curves and the borehole cuttings collected, this interval appears to be dominated by 10- to 20-foot thick sequences of thinly-layered fine-grained sand and silty clay, with 5- to 10-foot thick medium-grained sand beds between them. This character of thin layers is apparent in the single point resistivity curve (SPt) and a general character of materials becoming smaller in grain size downward (fining downward) is apparent in the 16-inch and 64-inch resistivity curves. However, the character of the SPt curve suggests that both fining upward and fining downward sequences are present in this transitional unit. The cuttings collected between 135 and 150 feet bgs are generally silty clay with sand; fine mica grains are abundant. At about 155 feet bgs the cuttings are coarse-grained sand with some silt and clay, with some quartz grains that have an orange colored coating. Cuttings from the interval 155 to 214 feet bgs are richer in sand and typically cannot be rolled into a thread of any size. These cuttings as silty sand and clayey sand. Abundant very fine mica grains and orange quartz sand grains are observed in this interval. At about 224 feet bgs, the cuttings material can again be rolled into about pencil thick threads before breaking. The Well Completion Report indicates that MW-3 is screened from 175 to 325 feet bgs with the filter pack extending up to about 130 feet bgs.

Lower Zone:

By about 240 feet bgs, the cuttings collected are dominantly fine-grained and the SPt curve indicates that these materials are thinly bedded. Varicolored clay appears in the cuttings at about 244 feet bgs, and dominates the materials encountered to the bottom of the borehole, with minor amounts of sand noted. The varicolored clays are composed of red (Munsell color: 7.5YR 6/3, *light brown*) and grey (2.5Y 6/2, *light brownish gray*) lumps in an olive-green matrix (2.5Y 5/4, *light olive brown*). The materials in this interval can be rolled into a fine thread, indicating a moderate to high content of clays. Rottman Drilling also notes red, brown, and gray clay at 244 feet bgs, and describes cutting materials as mainly clay with some fine- to medium-grained sand, which continues to the bottom of the boring at 344 feet bgs.

A moderate to large amount of material was observed coming out of the de-silting apparatus and mild to medium drilling chatter through the lower zone. During drilling, the rig operator expressed that the chatter was probably caused by drilling through hard clay layers. The cuttings contain clay with minor but variable amounts of sand, which is dominantly fine-grained, but ranges to coarse-grained. Cuttings in this interval contain abundant fine-grained biotite mica grains. Rottman Drilling describes the cuttings as fine- to medium-grained sand with clay lenses and clay with fine- to medium-grained sand lenses. The electric log curves indicate a thin-bedded character for these sediments with suggestions of both fining and coarsening upward sequences on a scale of about 10 to 20 feet per sequence. The observed chattering during drilling could also have been caused by cutting through coarser or more lithified sandy layers.

INTERPRETATIONS

The above observations appear to support an interpretation of three lithologic units encountered by this boring. Fine- to coarse-grained sands which dominate from ground surface to about 120 feet bgs. These sands could by composed of younger alluvium, older Quaternary age alluvium, or the Plio-Pleistocene Palm Spring Group (cf., Cassiliano, 2002), or some combination of these formations. The interbedded sand and silty clay between about 120 and 240 feet bgs that appears to coarsen upwards can be interpreted to be older Quaternary age alluvial fan materials or part of the Plio-Pleistocene Palm Spring Group. The dominantly fine-grained materials from 240 to 344 feet bgs are noted to contain varicolored clay. The appearance of varicolored clay indicates that this zone likely consists of sediments deposited as part of the Palm Spring Group.

Upper Zone:

The observed characteristics of the materials in this interval might be interpreted to belong to some alternative formations. The well site lies on an active alluvial fan, and Moyle (1982) maps the surface materials where MW-3 is drilled to be composed of Quaternary age younger alluvium. Moyle's map shows Quaternary age older alluvium to crop out within about 500 feet north of the well site. Moyle also shows Quaternary-Tertiary age continental deposits (most likely part of the Plio-Pleistocene Palm Spring Group) to crop out about 1.25 miles to the northeast of the well site. All of these mapped rocks could have characteristics consistent with the materials interpreted to have been encountered in the upper 120 feet bgs of the MW-3 borehole.

Based on geologic mapping by Moyle (1982; DWR 1968), the thickness of the younger alluvium is likely to be no more than about 20 feet at this location. The materials from 20 to 120 feet might be older alluvium, the Palm Spring Group, or a combination of these rock types. The older alluvium is described as "moderately sorted gravel, sand, silt, and clay" (DWR, 1968; Moyle, 1982). Descriptions of the older alluvium do not mention whether or not fine-grained mica is a distinctive component in these rocks. These materials were interpreted to underlie most of the valley floor and typically extend below the water table (DWR, 1968; Moyle, 1982). Moyle (1982) defines the "upper aquifer" in Borrego Valley as consisting of older and younger alluvium and he interprets (cross-section E-E') that these materials extend to a depth of about 80 feet bgs.

Cassiliano (2002) describes the Hueso Formation of the Palm Spring Group as containing buff to tan micaceous sandstone and siltstone. Occasional very coarse-grained sandstone and uncommon conglomerate beds are observed. Olive-green, gray, and tan siltstone is also present. The Hueso Formation is described as having a gradational or transitional contact with the underlying Tapiado Claystone (Cassiliano, 2002), which contains interbedded olive-green, blue-gray, and gray claystone, with biotite-rich siltstone and fine-grained sandstone.

One possible interpretation of the observed cuttings and electric log patterns is that a thin layer of modern alluvium directly overlies older alluvium, which extends to a depth of at least 120 feet. Another possible interpretation is that a relatively thin layer of modern alluvium directly overlies Palm Spring Group rocks at this location. The description of the Hueso Formation as dominantly sandstone, containing fine-grained mica, and grading downward into a finer-grained sedimentary unit is compatible with most observations. The observation of orange-stained quartz grains fits better with Cassiliano's description of the Arroyo Diablo Formation, the basal member of the Palm Spring Group. However, Cassiliano described the units based on outcrop located in different depositional basins, so the local unit descriptions may be different and the quartz grains could be derived by re-working the older unit. The lack of observation of fine-grained mica, as described by Cassiliano (2002) for the Hueso Formation, may be caused by the overall larger size grains in this zone.

It is possible that all three units (younger alluvium, older alluvium, and Palm Spring Group) are represented in the upper 120 feet of this borehole. A thin layer of younger alluvium (about 20 feet) is probably present. Some amount of older Quaternary alluvium is likely, because it is mapped as cropping out very close to the well site. A short interval at about 50 feet bgs displays high resistivity, which may suggest a basal coarse-grained unit deposited over Hueso Formation rocks. The occurrence of the Hueso Formation (cf., Cassiliano, 2002) in the upper part of this borehole is speculative because available mapping does not discriminate units within the Palm Spring Group, and the described materials do not correlate exactly to Cassiliano's description of this unit.

Transition Zone:

The characteristics of the bore-hole materials appear to change at about 120 feet bgs. Ross noted a color change from light yellowish brown (2.5Y 6/4 and 2.5Y 6/3) to light olive brown (2.5Y 5/6). The materials become more fine-grained and abundant fine-grained mica is noted. Between 130 feet and 240 feet bgs, sandy to silty clay, coarse-grained sand with some silt and clay, and clayey sand are described by Ross. Rottman describes this interval as having fine- to medium-grained sand, silty brown clay, and sand with silty brown clay. The electric log curves indicate thinly-bedded silt or clay and sands, and the logs and cuttings suggest a transition in this interval from dominantly sands at the top (120 feet bgs) to dominantly silts and clays at the base (240 feet bgs). These deposits could represent a finer-grained portion of the older alluvium unit. However, the interpretation that these rocks were deposited as part of the Palm Spring Group is preferred because:

- The presence of abundant fine-grained mica supports the interpretation that this section is part of the Palm Spring Group, but is not conclusive.
- The color of the materials and the interpreted interbedded nature of this interval are consistent with the description of the Hueso Formation (Cassiliano, 2002).
- The occurrence of varicolored clays in the underlying section along with the consistent fine-grained biotite component observed in the silty materials through both the middle and lower zones suggests that they are parts of one formation or group.
- This lithologic change of dominantly sandy to dominantly silty materials is consistent with the transition from Hueso Formation downward to the Tapiado Claystone within the Palm Spring Group as described by Cassiliano (2002).

Lower Zone:

Varicolored clays are described by both Rottman (red, brown, and grey) and Ross (red – 7.5YR 6/3, *light brown*; grey – 2.5Y 6/2, *light brownish gray*; matrix color - 2.5Y 5/4, *light olive brown*) starting at about 244 feet bgs. These colors appear to correlate well with the colors described for the Tapiado Claystone deposits (green, blue gray, gray; cf., Cassiliano, 2002) and for other descriptions of the Palm Spring Group containing red clay (e.g., DWR, 1964; 1968). Moyle (1982) picked the appearance of red clay in lithologic logs to interpret presence of Palm Spring Group rocks. The fine-grained and thin bedded nature of this unit is consistent with previous descriptions. The described character of the cuttings and the nature of the electric log curves are consistent with this interval representing the Palm Spring Group.

CONCLUSIONS

The upper, sand-rich deposits (0 to 120 feet bgs) encountered in the borehole of MW-3 are almost certainly composed of younger and older Quaternary age alluvial materials. However, it is difficult to say whether or not the lower part of this interval also contains deposits of the Palm Spring Group (Hueso Formation). The upper zone contains fine- to coarse-grained sands that are water-bearing below about 62 feet bgs. It appears likely that a transition from the upper zone of sands downward to silts and clays (120 to 240 feet bgs) represents part of the Palm Spring Group (possible transition from the Hueso Formation to Tapiado Claystone) because of the grain size and bedding character of the materials, the observed color pallet, and the presence of abundant fine-grained biotite. Rocks of the Palm Spring Group (possibly the Tapiado Claystone Formation) are encountered in the borehole of MW-3 at about 244 feet bgs and deeper because varicolored clays are present. The first appearance of Palm Spring Group rocks may occur in MW-3 as shallow as about 50 feet bgs where a change in character may appear on the electric logs. Palm Spring Group rocks are most likely encountered by about 120 feet bgs, near a noted change in hue and the first occurrence of fine-grained mica. By about 240 feet bgs, cuttings of red clay indicate certainly that Palm Spring Group rocks are present.

The portion of the upper lithologic zone or interval that is saturated lies above the uppermost screen and filter pack in MW-3. The filter pack and screened intervals in the well extend through the middle and lower lithologic zones discussed above. It is most likely that MW-3 is screened completely in portions of the Palm Spring Group. There may be a leaky connection into the upper sandy materials, though it is difficult to determine whether or not this is so.

References Cited:

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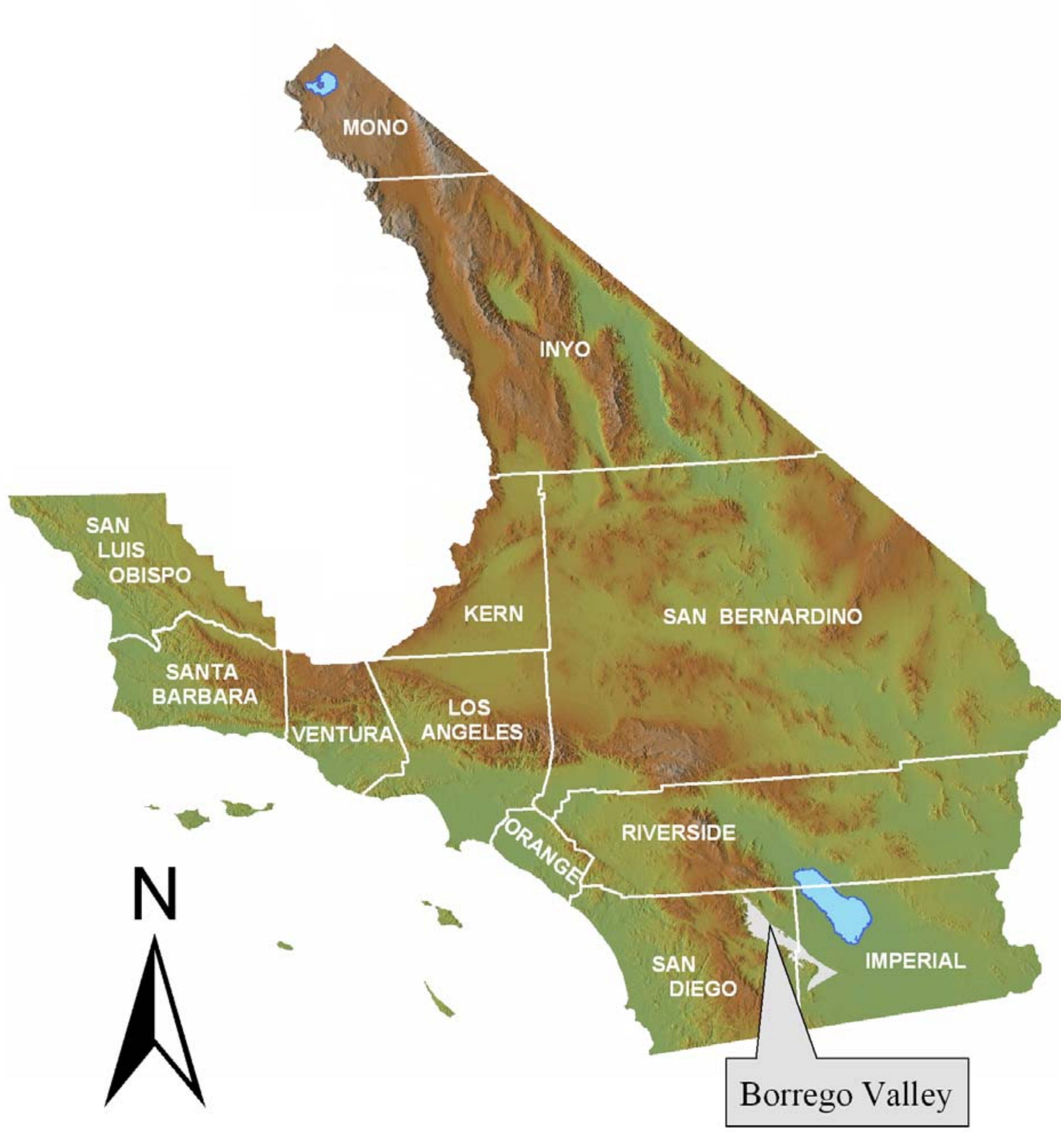

Figure 1. Location of Borrego Valley in southern California.

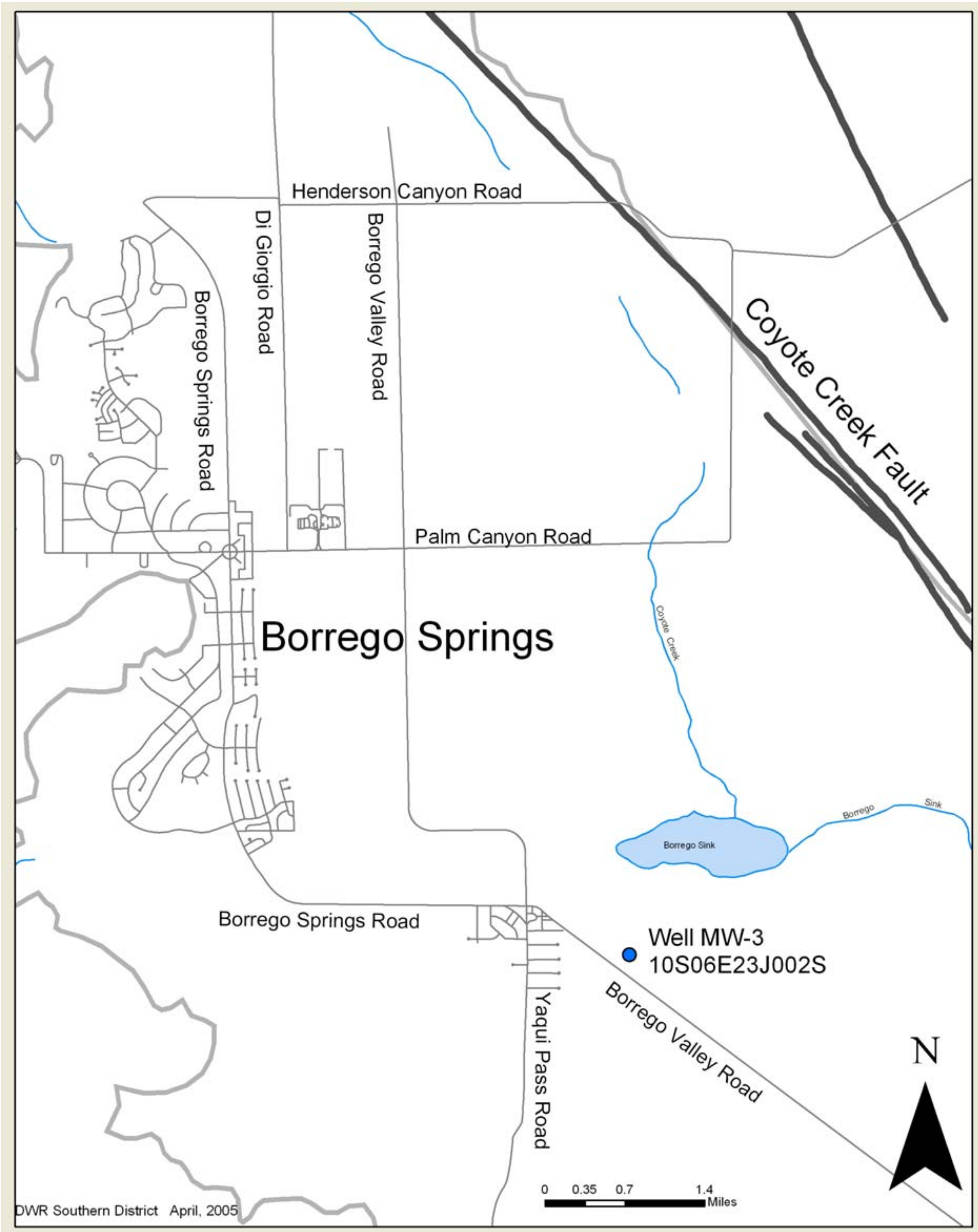

Figure 2. Location of Well MW-3 in Borrego Valley.